Design a Zener regulated DC Supply Voltage:

Specifications of Given Zener diode:

Breakdown Voltage (Zener Voltage) = 5.1V, Power dissipation (Zener Wattage) = 0.75W.

Max Forward Current (I_F) = 1A, take max. forward current 50 mA for experiment

Zener Diode as Voltage Regulator:

A DC voltage regulator circuit can be designed using a zener diode to maintain a constant DC output voltage across the load in spite of variations in the input voltage or changes in the load current. The function of a regulator is to provide a constant output voltage to a load connected in parallel with it in spite of the ripples in the supply voltage or the variation in the load current and the zener diode will continue to regulate the voltage until the diodes current falls below the minimum $I_z(min)$ value in the reverse breakdown region. It permits current to flow in the forward direction as normal, but will also allow it to flow in the reverse direction when the voltage is above a certain value - the breakdown voltage known as the Zener voltage. In breakdown the voltage across the Zener diode is close to constant over a wide range of currents thus making it useful as a shunt voltage regulator.

The purpose of a voltage regulator is to maintain a constant voltage across a load regardless of variations in the applied input voltage and variations in the load current. A typical Zener diode shunt regulator is shown in Figure. The resistor is selected so that when the input voltage is at $V_{IN}(min)$ and the load current is at $I_L(max)$ that the current through the Zener diode is at least $I_z(min)$. Then for all other combinations of input voltage and load current the Zener diode conducts the excess current thus maintaining a constant voltage across the load. The Zener conducts the least current when the load current is the highest and it conducts the most current when the load current is the lowest. If there is no load resistance, shunt regulators can be used to dissipate total power through the series resistance and the Zener diode. Shunt regulators have an inherent current limiting advantage under load fault conditions because the series resistor limits excess current. A Zener diode of break down voltage V_z is reverse connected to an input voltage source V_i across a load resistance R_L and a series resistor R_S. The voltage across the zener will remain steady at its break down voltage V_z for all the values of zener current I_Z as long as the current remains in the break down region. Hence a regulated DC output voltage $V_0 = V_Z$ is obtained across R_L, whenever the input voltage remains within a minimum and maximum voltage.

When selecting the zener diode, be sure that its maximum power rating is not exceeded.

I_{max}: Maximum current for Zener diode

$$I_{max} = \frac{Zener\ wattage\ (Power)}{Zener\ Voltage}$$

V_z Zener Diode standard voltage

Vin Input voltage(it is known)

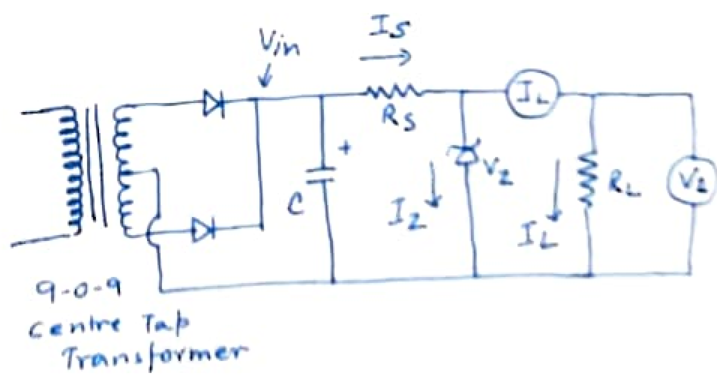
Vs Voltage across series resistance

V_L Voltage across the load resistance

I_S Current passing through the series resistance Rs

I_z Current passing through the Zener diode

I_L Current passing through the load resistance



The circuit is the zener shunt voltage regulator. In this circuit resistor Rs connected in with the diode to limit the current through the zener. In circuit cathode terminal of the zener diode is connected to the positive rail and anode is connected to ground so zener is connected in reverse bias.

As shown in circuit diagram, a centre tap transformer is used as input to construct DC supply of 5 V. Center tap is the contact made at the middle of the winding of the transformer. In the center tapped full wave rectifier two diodes are used. A full wave rectifier is a type of rectifier which converts both half cycles of the AC signal into pulsating DC signal*. let's take a look at the center tapped transformer. Because the center tapped transformer plays a key role in the center tapped full wave rectifier.* The number of AC components in the output is less than that of the input. These two diodes are connected to the center tapped secondary winding of the transformer. The positive terminal of two diodes is connected to the two ends of the transformer. Center tap divides the total secondary voltage into equal parts. The primary winding of the center tap transformer is applied with the AC voltage 220 V 50 Hz. Thus the two diodes connected to the secondary of the transformer conducts alternatively. For the positive half cycle of the input diode D1 is connected to the positive terminal and D2 is connected to the negative terminal. Thus diode D1 is in forward bias and the diode D2 is reverse biased. Only diode D1 starts conducting and thus current flows from diode and it appears across the load RL. So positive cycle of the input is appeared at the load. During the negative half cycle the diode D2 is applied with the positive cycle. D2 starts conducting as it is in forward bias. The diode D1 is in reverse bias and this does not conduct. Thus current flows from diode D2 and hence negative cycle is also rectified, it appears at the load resistor RL. By comparing the current flow through load resistance in the positive and negative half cycles, it can be concluded that the direction of the current flow is same. Thus the frequency of rectified output voltage is two times the input frequency. The output that is rectified is not pure; it consists of a dc component and a lot of ac components of very low amplitudes. We can improve the average DC output of the rectifier while at the same time reducing the AC variation of the rectified output by using smoothing capacitors to filter the output waveform. Smoothing or reservoir capacitors connected in parallel with the load across the output of the full wave bridge rectifier circuit increases the average DC output level even higher as the capacitor acts like a storage device. The smoothing capacitor converts the full-wave rippled output of the rectifier into a more smooth DC output voltage. To achieve a constant output voltage to a load connected in parallel a zener regulator is connected.
Zener Diodes is used to produce a stabilized voltage output with low ripple under varying load current conditions. By passing a small current through the diode from a voltage source, via a suitable current limiting resistor (RS), the zener diode will conduct sufficient current to maintain a voltage drop of Vout and a more stable output voltage can be produced.
The resistor, R_S is connected in series with the zener diode to limit the current flow through the diode with the voltage source, V_S being connected across the combination. The stabilized output voltage Vout is taken from across the zener diode. The zener diode is connected with its cathode terminal connected to the positive rail of the DC supply so it is reverse biased and will be operating in its breakdown condition. Resistor R_S is selected so to limit the maximum current flowing in the circuit.
With no load connected to the circuit, the load current will be zero, ($I_L = 0$), and all the circuit current passes through the zener diode which in turn dissipates its maximum power. Also a small value of the series resistor R_S will result in a greater diode current when the load resistance R_L is connected and large as this will increase the power dissipation requirement of the diode so care must be taken when selecting the appropriate value of series resistance so that the zener's maximum power rating is not exceeded under this no-load or high-impedance condition.
The load is connected in parallel with the zener diode, so the voltage across R_L is always the same as the zener voltage, ($V_{RL} = V_Z$). There is a minimum zener current for which the stabilization of the voltage is effective and the zener current must stay above this value

operating under load within its breakdown region at all times. The upper limit of current is of course dependent upon the power rating of the device. The supply voltage V_S must be greater than V_Z.

One small problem with zener diode stabilizer circuits is that the diode can sometimes generate electrical noise on top of the DC supply as it tries to stabilize the voltage. Normally this is not a problem for most applications but the addition of a large value decoupling capacitor across the zener's output may be required to give additional smoothing. The stabilized output voltage is always be the same as the breakdown voltage VZ of the diode.

Ripple factor

The ripple factor is used to measure the amount of ripples present in the output DC signal. A high ripple factor indicates a high pulsating DC signal while a low ripple factor indicates a low pulsating DC signal.

Ripple factor is defined as the ratio of ripple voltage to the pure DC voltage

The ripple factor is given by

$$\gamma = \sqrt{\left(\frac{V_{rms}}{V_{DC}}\right)^2 - 1}$$

Calculation of Components to be used to construct DC power supply 5 V:

Given:

Transformer Voltage (As input source) = 9 V

Zener Voltage (Output voltage) = 5 V

Power of Zener 100mW

Ripples acceptable 10% of V_{output}

Output Load Current maximum = 25 mA

$V_{dc} = \sqrt{2}.\ V_{ac} = 1.414 \times 9 = 12.72$ V

$I_Z = P_Z / V_Z = 100mW / 5\ V = 20$ mA

$R_L = V_{out} / I_L = 5 / 25mA = 200\ \Omega$

$I_T = I_L + I_Z = 25mA + 20mA = 45mA$

Capacitor value depends on I_{dc}, frequency and ripples

$V_{ripples} = I_T / 2\pi FC = 45mA / 2\pi\ 100\ C$ (V ripples = 0.5V)

C = 143 µF (near value available 100µ F or 220µ F or you can make value of c by paralleling Capacitors)

$R_S = (V_{in} - V_{out}) / I_T = (12.72 - 5.1) / 45\ mA = 168\ \Omega$

Power of Series Resistance $P_{RS} = I^2 R_S =$ 0.34 Watt

Power of Load Resistance $P_{RL} = I^2 R_L = 0.13$ Watt

Applications of Zener Diode:

- Zener diode is used in voltage regulator circuits to provide regulated DC voltage.
- Used in wave form clippers to remove unwanted portion of signal.
- Zener diode is used in voltage comparator applications to produce reference voltage.
- Used in electronic circuits to protect the circuit from high voltages.
- Used in power supply circuits.

Precautions:

1. While doing the experiment do not exceed the readings of the diode. This may lead to damaging of the diode.
2. Connect voltmeter and ammeter in correct polarities as shown in the circuit diagram.
3. Take care of capacitor connection, check polarity. Minus sign of capacitor is to be connect to the ground / common point of DC supply.
4. Do not switch ON the power supply unless you have checked the circuit connections as per the circuit diagram.

Result: The characteristics and Voltage Regulation of Zener diode are studied.

DC power supply Voltage achieved Vout =

IL maximum=

$V_{ripples}$=

Load regulation=

Line regulation=

Ripple factor=

$$\text{Load Regulation} = \frac{V_{\text{No Load}} - V_{\text{Load}}}{V_{\text{No Load}}} \text{ X100}$$

R_L	I_L	V_L
1 K		
470 E		
220E		
100 E		

Viva Questions:

1. What is the difference between p-n Junction diode and zener diode?

Ans: A zener is designed to operate stably in reverse breakdown, which is designed to be at a low voltage, between 3 volts and 200 volts. The breakdown voltage is specified as a voltage with a tolerance, such as 10 volts ±5%, which means the breakdown voltage (or operating voltage) will be between 9.5 volts and 10.5 volts.
A signal diode or rectifier will have a high reverse breakdown, from 50 to 2000 volts, and is NOT designed to operate in the breakdown region. So exceeding the reverse voltage may result in the device being damaged. In addition, the breakdown voltage is specified as a minimum only. Forward characteristics are similar to both, although the zener's forward characteristics is usually not specified, as the zener will never be used in that region. A signal diode or rectifier has the forward voltage specified as a max voltage at one or more current levels.

2. What is break down voltage?

Ans: The breakdown voltage of a diode is the minimum reverse voltage to make the diode conduct in reverse.

3. What are the applications of Zener diode?

Ans: Zener diodes are widely used as voltage references and as shunt regulators to regulate the voltage across small circuits.

4. What is cut-in-voltage ?

Ans: The forward voltage, at which the current through the junction starts increasing rapidly, is called the knee voltage or cut-in voltage. It is generally 0.6v for a Silicon diode.

5. What is voltage regulator?

Ans: A voltage regulator is an electronic circuit that provides a stable dc voltage independent of the load current, temperature and ac line voltage variations.

6. What is the doping concentration in Zener diodes?
7. Can we use Zener diode as a switch?
8. What is PIV of Zener?
9. What will happen if P-N regions are heavily doped in Zener diode?
10. List the other Zener diodes with different breakdown voltages.
11. Is the breakdown region in Zener really destructible?
12. What is a zener diode?
13. How the name of the Zener came?
14. What is cause of reverse breakdown?
15. What is zener voltage?
16. Write the Symbol for the Zener diode.
17. What are the differences between the PN junction diode and Zener diode fabrication?
18. What are the applications of Zener diode?
19. What are the different types of breakdowns in semiconductor junctions?
20. Compare Zener Breakdown and Avalanche breakdown?
21. What is the max value of voltage of Zener breakdown devices?
22. Zener diode is generally used in ________ biased condition. When Zener diode is forward biased, it acts as a _________.

Explain what is a dc power supply?

The part of Equipment that converts ac in to dc is called dc power supply.

Explain what is a rectifier?

A rectifier is a device which converts ac Current (or Voltage) into unidirectional current (or Voltage).

Explain what is the PIV of a diode in a rectifier circuit?

Peak Inverse Voltage (PIV) is the maximum possible voltage that occurs across a diode when it is in reverse biased. If the applied voltage in reverse biased condition exceed peak inverse voltage (PIV) rating of the diode, then the diode may get damaged.

What id difference between power and energy?

Energy is defined as the capacity of a physical system to perform work. In the context of electric circuits, energy (w) is related to power by the following relationship p = vi =dw/dt

So the difference is that power is the rate of change of energy.

Differentiate between Kirchhoff's First law and Kirchhoff's Second law?

Kirchhoff's First law: The total current leaving a point on an electrical circuit = total current entering

Kirchhoff's Second law: The sum of the voltages round any circuit = net "IR" drop in the circuit

What is Kirchoff's Current Law (KCL)?

The algebraic sum of all the currents entering or leaving a node in an electric circuit is equal to zero. In other words, the sum of currents entering is equal to the sum of currents leaving the node in an electric circuit.

What is a capacitor and what does it do?

Capacitors are widely used as parts of electrical circuits in many common electrical devices. Unlike a resistor, an ideal capacitor does not dissipate energy. Instead, a capacitor stores energy in the form of an electrostatic field between its plates.

How does a capacitor store an electrical charge?

Electrical Energy in Capacitor stores in Potential Charge form. The energy stored in a capacitor is almost entirely in the electric field produced between the plates. It takes energy from a battery or some other power source to move electrons to one of the plates and away from the other.

What is the function of the capacitor?

A capacitor (originally known as a condenser) is a passive two-terminal electrical component used to store energy electrostatically in an electric field. The forms of practical capacitors vary widely, but all contain at least two electrical conductors (plates) separated by a dielectric (i.e. insulator).

Define Ampere?

The quantity of total charge that passes through an arbitrary cross-section of a conducting material per unit second is defined as an Ampere.

Mathematically,

I =Q/t   or, Q = It

Where, Q is the symbol of charge measured in Coulombs (C), I is the current in amperes (A) and t is the time in seconds (s).

Could you measure current in parallel?

Answer: No, Current is always measured through (in series with) a circuit element.

What is the function of Capacitor in Electrical Circuits?

A capacitor is a passive circuit element that has the capacity to store charge in an electric field. It is widely used in electric circuits in the form of a filter.

How to calculate Energy stored in a capacitance?

Energy stored = ½ C V2 Joules, where C is in farads and V in volts

What is Voltage Divider Rule?

Voltage divider rule provides a useful formula to determine the voltage across any resistor when two or more resistors are connected in series with a voltage source.

Could you measure Voltage in series?

No, Voltage is always measured across (in parallel with) a circuit element.

State and define Ohm's Law?

It is the most fundamental law used in circuit analysis. It provides a simple formula describing the voltage-current relationship in a conducting material.

Statement: The voltage or potential difference across a conducting material is directly proportional to the current flowing through the material.

V = IR or I =V/R   or R =V/I

Where, the constant of proportionality R is called the resistance or electrical resistance, measured in ohms (Ω).

What is ohm's law?

Ohm's Law deals with the relationship between voltage and current in an ideal conductor. This relationship states that: The potential difference (voltage) across an ideal conductor is proportional to the current through it. The constant of proportionality is called the "resistance", R. Ohm's Law is given by: V = I R

What are the limitations of ohm's law?

The main limitations of ohm's law are:

it is valid for the conductors whose physical dimensions are not change with the variation of temperature.

Explains Insulator, metal and semiconductor?

Insulator: insulator is a material which does not allow to flow of current trough itself is called insulator. Example: wood, glass etc

Conductor:-metal is a material which allow to flow of current trough itself is called Conductor. Example: Al, Ag, Steel etc.

Semiconductor:-a semiconductor is a material which hasthe resistivity in between semiconductor and insulator. Example: Ge, Si, C etc

Define Ohm's Law for A.C (Alternating Current)?

Everything else would remain same only the resistance will be replaced with Impedance, which is defined as the opposition to the flow of A.C.

What is Superposition Theorem?

Superposition theorem is extremely useful for analyzing electric circuits that contains two or more active sources. In such cases, the theorem considers each source separately to evaluate the current through or voltage across a component. The resultant is given by the algebraic sum of all currents or voltages caused by each source acting independently. Superposition theorem can be formally stated as follows:

"The current through or voltage across any element in a linear circuit containing several sources is the algebraic sum of the currents or voltages due to each source acting alone, all other sources being removed at that time."

What is the difference between Voltages or Potential Difference?

Voltage or potential difference between two points in an electric circuit is 1V if 1J (Joule) of energy is expended in transferring 1 C of charge between those points.

It is generally represented by the symbol V and measured in volts (V). Note that the symbol and the unit of voltage are both denoted by the same letter; However, it rarely causes any confusion. The symbol V also signifies a constant voltage (DC) whereas a time-varying (AC) voltage is represented by the symbol v or v (t)

What does the term "Voltage Regulation" means?
Voltage regulation (VR) is an important measure of the quality of a source. It is used to measure the variation in terminal voltage between no load (IL =0, open circuit) and full load (IL = IFL)
State and define Norton's Theorem?
Thevenin's equivalent circuit is a practical voltage source. In contrast, Norton's equivalent circuit is a practical current source. This can be formally stated as:
"Any two-terminal, linear circuit, of resistors and sources, can be replaced by a single current source in parallel with a resistor."
To determine Norton's equivalent circuit, Norton current, IN, and Norton resistance, RN , are required. The following steps outline the procedure required:

1. Remove the load resistance, RL.
2. IN is the SC current through the load terminals and
3. RN is the resistance across the load terminals with all sources replaced by their internal resistances. Clearly RN = RTH.

What does the term Power Factor shows?
The term cos φ is called the power factor and is an important parameter in determining the amount of actual power dissipated in the load. In practice, power factor is used to specify the characteristics of a load.
For a purely resistive load φ = 0 Degree, hence Unity Power Factor
For a capacitive type load I leads V, hence Leading power factor
For an inductive type load I lags V, hence Lagging power factor
Clearly, for a fixed amount of demanded power P, at a constant load voltage V, a higher power factor draws less amount of current and hence low I2R losses in the transmission lines. A purely reactive load where φ → 900 and cos φ → 0 will draw an excessively large amount of current and a power factor correction is required.
What is DC Current source? Differentiate between ideal and non-ideal current sources
A current source, unlike the DC voltage source, is not a physical reality. However, it is useful in deriving equivalent circuit models of semiconductor devices such as a transistor. It can also be subdivided into ideal and non-ideal categories.
The Ideal Current Source By definition, an ideal current source that produces a current which is independent of the variations in load. In other words the current supplied by an ideal current source does not change with the load voltage.
Non-Ideal or Practical Current Source The current delivered by a practical current source falls off with an increase in load or load voltage.
Differentiate between Low Pass, High pass and Band Pass filter?
Filters form a vital part in electrical networks especially where a particular frequency range is of prime concern. For instance, a radio station is broadcasting a transmission at a frequency of 100 MHz. This means that it is required to design a receiving filter which allows only 100 MHz frequency to pass through whilst other frequencies are filtered out. An ideal filter will attenuate all signals with frequencies less than and greater than 100 MHz thus providing the best channel sound quality without any distortion.
Low Pass Filter: A low pass Filter allows low frequencies to pass through the circuit whereas high frequencies are severely attenuated or blocked.
High Pass Filter: A high pass filter, as the name suggests, allows high frequencies to pass through the circuit whilst low frequencies are attenuated or blocked. The cut-off point or bandwidth concept is the same as in the low pass filter.

Band Pass Filter: A band pass filter permits a certain band of frequencies to pass through the network which is adjusted by the designer. It is simply an amalgamation of a low pass and a high pass filter.

Voltage regulation requires

A.only line regulation.
B.only load regulation.
C.a constant load.
D.load and line regulation. Answar D

What is current?

An electric circuit is formed when a conductive path is created to allow free electrons to continuously move. This continuous movement of free electrons through the conductors of a circuit is called a current, and it is often referred to in terms of "flow," just like the flow of a liquid through a hollow pipe. Current is measured in amperes (A)

What is voltage?

Voltage is the difference in electrical potential between two points in a circuit. It's the push or pressure behind current flow through a circuit, and is measured in (V) volts. The force motivating electrons to "flow" in a circuit is called voltage. When we speak of a certain amount of voltage being present in a circuit, we are referring to the measurement of how much potential energy exists to move electrons from one particular point in that circuit to another particular point

What is resistance?

Free electrons tend to move through conductors with some degree of friction, or opposition to motion. This opposition to motion is more properly called resistance. The amount of current in a circuit depends on the amount of voltage available to motivate the electrons, and also the amount of resistance in the circuit to oppose electron flow. For this reason, the quantities of voltage and resistance are often stated as being "between" or "across" two points in a circuit. A very high resistance allows a small amount of current to flow. A very low resistance allows a large amount of current to flow. Resistance is measured in ohms (Ω).

What do you mean by RMS value?

The steady current which when flow through a resistor of known resistance for a given time produces the same amount of heat as produced by the alternating current when flows through the same resistor for the same time is called RMS value of the alternating current

What is Voltmeter?

A voltmeter is an instrument used for measuring the electrical potential difference between two points in an electric circuit.

What is Ammeter?

An ammeter is a measuring instrument used to measure the electric current in a circuit. Electric currents are measured in amperes (A), hence the name. Smaller values of current can be measured using a millimeter or a micrometer.

Constant voltage source is

a) active and bilateral
b) passive and bilateral
c) active and unilateral
d) passive and unilateral